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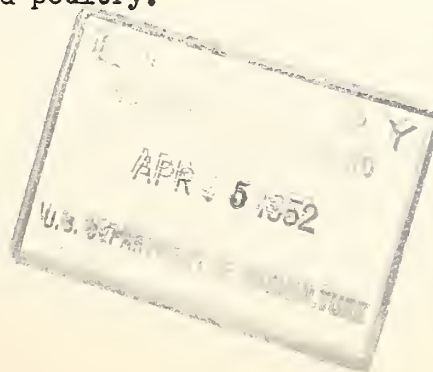
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UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Administration

X THE USE OF UREA AS A FEEDSTUFF X

Urea is a comparatively simple chemical compound which has occupied a unique place in chemistry and nutrition. It was described and synthesized by a German chemist more than 120 years ago. Its synthesis marked a milestone in organic chemistry. Much has been written about its role in nutrition.

In humans and mammals, urea is one of the main products resulting from the breakdown (metabolism) of proteins and thereby a principal excretory product. Another still simpler product is ammonia. Urea is classed as a non-protein nitrogen compound having the formula $\text{N}_2\text{H}_4\text{CO}$. The nitrogen content is approximately 46.7 percent. The reverse process by which urea is rebuilt into protein occurs in ruminants through the medium of microorganisms. In the rumen, microorganisms with the ability to use simple compounds in the building of complex living matter utilize urea to build up the proteins of their cells. Since the life span of the microorganisms is short, the dead cells are available to be digested in the alimentary tract of the ruminant host thereby supplying protein to the body tissues. Other simple nitrogen compounds likewise serve as nutrients for these microorganisms.

A German scientist, W. Voltz, demonstrated the utilization of urea by sheep in 1919. He restricted sheep to a protein-poor ration composed of 500 grams of chopped oat straw, 400 grams of molasses, and 150 grams of cooked potato starch. To this was added 30 grams of urea. Adult sheep maintained body weight and lambs gained in weight. Numerous German investigations followed Voltz's discovery regarding various debated aspects of the problem. Fingerling's report in 1937 added convincing proof that urea can be utilized by calves to supply a part of the protein needs for growth. Hart and associates at the Wisconsin Station initiated studies on urea utilization in 1936 or thereabouts. Since that time, a large number of studies have been reported by research agencies of this country. The subject matter has concerned principally dairy cattle, sheep and beef cattle of various ages and under various conditions extending from winter ranges to intensive dairy farming. From the 200 references and more now in the scientific literature, it is apparent that a large quantity of information exists on which to judge the merits of urea as a feed supplement. Its usefulness for cattle, sheep, goats and other ruminants is abundantly demonstrated. It is not utilized to an economically significant extent by swine and poultry.



Urea is manufactured and used for a number of industrial purposes, the principal ones being in the making of plastics, and as a fertilizer and a feed supplement. During World War II, use of urea as a supplement in mixed feeds rose to significant proportions under the pressure of protein shortages. While pure urea contains over 46 percent nitrogen, the product as offered for feeding purposes has contained in the neighborhood of 42 percent nitrogen which is the equivalent of 262 percent protein. One pound of this product accordingly contains as much nitrogen as 6.4 pounds of cottonseed or soybean meal of 41 percent protein content. In illustration of its mode of use, the fattening of beef cattle may be cited. A steer weighing 700 pounds requires approximately 12 pounds of total digestible nutrients, and 1.4 pounds of digestible protein daily. A ration of 11 pounds of corn, 6 pounds of mixed hay and 1 pound of cottonseed meal will fill these requirements. If the cottonseed meal is omitted and 0.16 pound of urea added as nitrogen replacement there would need to be added about 0.8 pound additional corn. In lieu of the corn, 1 pound of blackstrap molasses may be added, all for the purpose of supplying the total digestible nutrients lost by the removal of the cottonseed meal. In this connection, the conventional expression is that one pound of urea and 6 pounds of grain are required to replace 7 pounds of a 41 percent protein feed. It is obvious that comparatively small amounts of urea are required to satisfy the nitrogen requirements of ruminants under average conditions. In the example for beef steers just cited, the percentage in the total ration is only 0.9 percent and in the concentrate mixture about 1.3 percent.

About 12 years ago, the Association of American Feed Control Officials set up definitions or standards for regulation of the use of urea in feed mixtures presumably to stress the small amount needed for effective utilization and partly as protection to the user against possible poisoning action of excessive amounts. The definitions as they stand today are as follows:

"UREA. (a) Urea and ammonium salts of carbonic and phosphoric acids may be used as ingredients in feeds for cattle, sheep, and goats only provided it is used in such limited quantities as to insure that the total amount present shall not constitute the equivalent of more than $1/3$ of the total protein in the ration excluding roughage and pasture; and that the following statement of guaranty of crude protein for feed containing these materials shall be used: Crude protein, not less than _____ percent. (This includes not more than _____ percent equivalent crude protein from non-protein nitrogen.)

"(b) If a feed contains more than 3 percent urea the label shall bear a statement of proper usage, and the following in type of such conspicuousness as to render it likely to be read and understood by ordinary individuals under customary conditions of purchase and use.

"Warning! This feed should be used only in accordance with directions furnished on the label."

Efficiency of utilization

Experimental work on the efficiency with which urea is utilized in the digestive tract of cattle and sheep has shown varying figures depending on the diet, the level of protein in the original ration, the level at which urea is fed and other factors. As is true with protein feeds generally, better efficiencies are obtained with reduced or minimum levels than with excessively high levels. The ingredients in the diet are important also. A carbohydrate-rich feed is a great aid presumably in providing a quick source of energy for the microorganisms. Corn serves very satisfactorily. Additions of small amounts of molasses are very effective and much to be preferred over additions of large amounts. Most of the experiments appear to have shown that relatively less urea nitrogen is digested and absorbed by the animal as formed protein products (amino acids) than is true for natural feed protein nitrogen. The higher comparative utilization figures of 80 percent and above generally occur where the urea allowance is on the low side. Attempts to equal or exceed the optimum animal production records achieved by feeding liberal levels of natural protein supplements by the substitution of urea have not been fully successful as yet. In other words, growth rates in steers are more likely to be of the order of 2 pounds per day on urea supplement as compared to 2.5 pounds and better on cottonseed meal for example. Nevertheless, the daily gains and total feed utilization values per unit of gain are very satisfactory. It is rather obvious that urea can be used to best advantage in a mixed feed and consequently for feeding those classes of livestock which are receiving a fairly liberal allowance of a concentrate mixture.

Dangers of toxicity

By its very nature, urea is a toxic product in the sense that the animal body cannot tolerate the accumulation of large amounts and normally excretes through the urine the urea resulting from metabolism of protein. Reports have appeared of damage to kidneys and the poisoning of cattle and sheep fed high doses of urea. The range between the toxic dose and the amounts recommended and needed for protein replacement, while not very wide, is still sufficient to preclude dangers of poisoning under good control and reasonable care in formulation and mixing of diets. Proper mixing equipment and close supervision of the operations are essential in safeguarding the preparation of feed mixtures. The situation is somewhat analagous to poisoning from consumption of large amounts of salt. With access to water, the animal quickly excretes the excess thus relieving the danger. Good diets with adequate carbohydrate content which are favorable to maximum multiplication of the microorganisms in the rumen seem to lessen the chances for toxic effects by raising the tolerance limits. Molasses is reported as being especially effective.

Urea in the feeding of beef cattle

Urea has been used in the feeding of beef cattle both on pasture and range and in the feed lot. In the feed lot, generous levels of concentrates are ordinarily fed or the roughage portion of the ration may be ground, thus permitting the mixing of the needed amount of urea with the other feeds. A common method is to mix the urea and molasses and then add this material to the rest of the concentrate or ground portion of the ration. As much as 0.35 pound of urea has been fed to steers with good results. This amount is generally well

in excess of requirements. As already illustrated with steers, 0.25 pound of urea or even less is generally sufficient. Perhaps one reason why maximum gains of 2.5 pounds per day or better are not as readily obtained with urea as with cottonseed meal or other similar supplement is the appetite stimulation achieved by these supplements. Care in selection of an appetizing urea-supplemented mixture is important, therefore.

In recent Iowa experiments with fattening steers, soybean meal, urea and molasses were compared singly and in combinations as supplements to shelled corn and hay. Supplementations with urea produced average daily gains of 2.25 pounds per day which was the equal of soybean meal additions and considerably cheaper under the prevailing price conditions. Molasses was not especially beneficial as a supplement in these tests.

In many areas, supplemental feeding of one to two pounds of cottonseed or soybean meal per head to range cattle during the winter months is common practice. Somewhat more than this allowance of a concentrate containing 20 percent of protein generally needs to be fed. A mixture of urea, molasses and ground grain in pellet form has been used effectively in Oklahoma experiments. A mixture with a protein equivalent of 25 percent has given very good results. Such a mixture has been used successfully in the feed lot, also.

One of the most effective ways of using urea is in wintering rations of cattle either for maintenance of mature stock or for young growing heifers and steers. At the same time, good use can be made of low-grade dry roughages such as corn cobs, oat straw, wheat straw, soybean straw, and the poorer grades of hay along with various silages. Molasses is a valued supplement for supplying available carbohydrates and for improving the palatability of the ration as well as a carrier of the urea. Combinations of urea, molasses, and roughages such as those named plus mineral and vitamin A supplements provide for maintenance, and in the case of young stock that is to be turned out on pasture in the spring or is to be fattened, for the desired growth and development. Such mixtures provide excellent media for the multiplication of rumen microorganisms with utilization of the urea as well as of the breakdown of celluloses in the roughages into simple sugars. Feeding tests at the Purdue Experiment Station have demonstrated the economies which can be achieved by use of various combinations of these less appreciated feedstuffs and the savings of other protein supplements which can be effected.

Urea for sheep feeding

In the feeding of lambs, results have not been as uniformly good as in the case of beef cattle. Tests in Illinois showed good utilization of urea as long as the total protein equivalent was kept at a medium level of around 12 percent. It was concluded that lambs were not able to utilize urea at a sufficiently rapid rate to meet their requirements for maximum rate of growth, although 3.16 percent urea was fed in the concentrate mixture. New York experiments showed that addition of the amino acid, methionine, to a diet of urea, corn grain, corn silage and hay brought about considerable improvement over those with urea alone and approximating the results with a natural protein supplement. As was the case with cattle tests in Oklahoma, the use of the pelleted feed containing the equivalent of 25 percent of protein was quite

satisfactory for lambs. It seems likely that more attention to formulation of suitable urea-containing diets which encourage microorganism growth are important in sheep feeding.

Results of feeding urea to dairy cattle

The results of experiments in using urea as a protein substitute in feeding dairy cows for milk production have been variable. Results from Wisconsin and Massachusetts have shown that urea is effective in replacing the protein in the grain ration of dairy cattle, while results from England and Norway have not been so encouraging.

The results from Wisconsin, where urea was used to increase the protein level of the grain ration from 10 percent to an equivalent of 18 percent protein, showed that almost as much milk was produced as when linseed meal was used to increase the protein content of the grain ration to 18 percent. Timothy hay and corn silage were fed as roughages. On the basis of this experiment and other work in this country, the concentrate mixture should not contain more than 2 or 3 percent of urea.

In England, in extensive experiments with 274 cows, the addition of enough peanut meal to increase the protein content of the ration from 12.9 percent to 17.9 percent resulted in a significant increase in milk production. On the other hand, the addition of enough urea to the same ration to increase the protein equivalent to 17.9 percent resulted in no significant change in milk production. The results further showed that when more than 3 ounces of urea was fed per day, there was a depressant effect on milk production. If this is true, and the amount of urea is 3 percent of the grain ration, then a cow should not receive more than 4 to 5 pounds of grain per day which would preclude the use of such a grain mixture with high-producing cows.

Most all of the experimental data show quite definitely that urea is not effective when added to high-protein grain rations for milk-production purposes. Thus urea should not be added to grain rations already containing 14 percent to 18 percent protein. It is probably effective when added to grain rations containing 10 percent or less protein, or when added to rations containing only home-grown grains. In areas where high-protein forages, such as good quality alfalfa hay, early cut grass, legume mixtures, or grass silage, are fed along with home-grown grains, it is doubtful that urea would increase milk production. Of course it is also doubtful that the addition of a protein concentrate under such conditions would increase milk production.

It is recommended that urea not be used to increase the protein level of grain rations to above 16 percent. It should not be added in quantities greater than 2 percent of the grain ration and must be mixed thoroughly with the grain ration.

Urea is not palatable to cows and is not consumed as readily as the oil meals. Urea should not be mixed with cheap feeds high in fiber in such a way as to meet the protein equivalent necessary. Such a grain mixture would be of poor quality and not satisfactory for milking cows. For growing dairy stock and for maintenance of dry cows, the procedures used in the feeding of urea to comparable classes of beef cattle may be followed.

Economics

Whether urea will be used in place of protein concentrates is largely a matter of economics and availability of grains, other protein concentrates and forages, taking into consideration the prices of the protein and carbohydrate concentrates. In the Eastern States where the differences in prices of protein and carbohydrate concentrates are not often greatly different, it would seem doubtful that urea would be used to any large extent except when the supplies of protein concentrates are limited. On the other hand, in the Midwest where the carbohydrate concentrates are generally lower in price compared to the protein concentrates, the use of urea would be more justified. If the cost of one pound of urea and six pounds of carbohydrate concentrate is less than that of seven pounds of protein concentrate then it would be economical to use urea.

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